The authors assess the quality of ALES-retracked altimetry data in terms of reproducing temporal variations of sea level along the Norwegian coast, specifically the annual cycle and the trend, by comparison with available tide gauge data. They then use the altimetry data in combination with observations from hydrographic stations (with no tide gauge data there) to compare steric height variations to the total sea level variations.

Both issues of the paper, the quality assessment of the ALES-retracked altimetry as well as the analysis of sea level variations along the Norwegian coast are interesting for the reasons stated by the authors. However, both issues need more in-depth consideration. Also the methodology needs some additional descriptions.

It is not totally clear to me why the semi-annual cycle is fitted (eq. 1). It is never addressed anywhere later in the paper (or I have misunderstood). Is it included only to prevent, in case of data gaps, that the running annual mean reveals part of the seasonal signal, or aliasing issues? This has to be explained. If there is a signal with amplitudes comparable to that of the annual cycle, it would also be interesting to see, as additional part of the quality assessment, how, for this frequency, ALES-retracked altimetry compares to the tide gauges.

We would like to thank the reviewer for the comment on the semi-annual cycle.

We fitted the semi-annual cycle to account for asymmetry in the shape of the seasonal cycle. Leaving this signal in would further increase the autocorrelation of the residuals, reduce the number of degrees of freedom and the confidence intervals of the sea-level trend. However, we do not show the results for the semi-annual cycle (Fig. R1) because it contributes little to the seasonal cycle of sea-level (Fig. 6). Indeed, the ratio between the amplitude of the annual and of the semi-annual cycle ranges between 4, at Rørvik, and 21, at Oslo. Still, Figure R1 indicates that it is preferable to estimate the semi-annual cycle than leave it out.

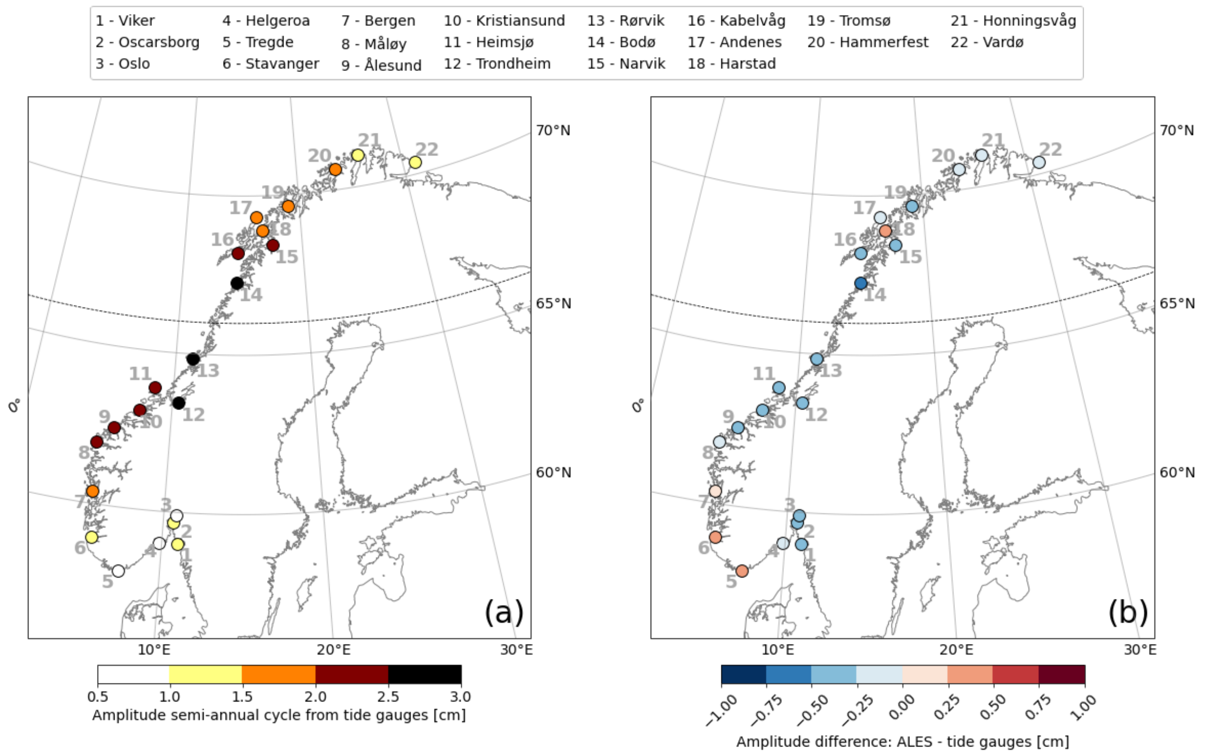

Fig. R1: Comparison between the amplitude of coastal sea-level semi-annual cycle from in situ measurements and area-averaged remote-sensing data. At each tide gauge location, amplitude of the semi-annual cycle from the tide gauges (a) and difference between the amplitude of the semi-annual cycle from the ALES-reprocessed altimetry dataset and the tide gauges (b). The black, dashed line indicates the 66°N parallel.

The authors state that sea level data from the tide gauges have been corrected for geoid height changes with respect to GIA. Is this correction applied to the altimetry data as well? If geoid height change from GIA is considered, then also instantaneous adaptation from changed loading caused by the Greenland ice melt should be included, which will probably outperform the GIA effect in most regions along the Norwegian coast (Siegismund et al, 2020).

We would like to thank the reviewer for the comment.

Unlike the satellite altimetry dataset, the tide gauge data was corrected for geoid changes with respect to the GIA. We have recorrected the tide gauge data not to account for the geoid height change correction, and we have found a better agreement between the sea-level trends from tide gauges and satellite altimetry. This led to a modification of Figs. 8 and 9.

Why is, at the end, not the full sea level variation budget considered, but only the steric effect? The abstract states performance of the sea level budget. Consideration of the full budget would give the whole study more weight. If this is not intended the authors should explain the reasons to the reader.

We apologize for the misleading title of the section as our intention was to focus on the steric contribution. We have now changed the title and made it clearer that we only focus on the temperature and salinity contribution to sea level (this issue was also pointed out by Reviewer 1).

In the paper, we only focus on the steric contribution to the sea-level while assessing the synergy between satellite altimetry and in-situ data along the coast of Norway. The consideration of the full budget would be the object of a further investigation in the future.

It isn't clearly stated how the optimal distances from and along the coast for spatial averaging the altimetry data are found. I guess, a set of distances is defined and the correlations are computed for each element? Please explain.

We would like to thank the reviewer for the comment. To clarify this point, we have provided additional information in the manuscript:

(Lines 227 – 234) "To select the minimum and the maximum distances from the coast, we have proceeded as follows. We have set the minimum distance from the coast following the recommendations on how to use the ALES dataset: these suggest to discard data within 3 km from the coast. We have then performed a sensitivity analysis and found only small differences between the results obtained applying a maximum distance of either 40 km or 20 km. To only focus on the observations over the continental shelf, we have selected the range of distances from the coast between 5 and 20 km. Similarly, we have performed a sensitivity test on the distance from the tide gauge allowing it to range between 15 and 400 km: as before, we have found little difference in the final results".

It would be nice to see a direct comparison of conventional altimetry and ALES-retracked altimetry for the Norwegian coast to see both, the improvements/changes in the observations dependend on location (and specifically distance from the coast) as well as the added value caused by the improvements when investigating spatio-temporal variations of sea level along the Norwegian coast. Direct comparison to Breili et al (2017) is not feasible due to different methodology and period.

We would like to thank the reviewer for the comment. We have repeated the analysis using along-track (L3) conventional satellite altimetry dataset (SEALEVEL_GLO_PHY_L3_REP_OBSERVATIONS_008_062 downloaded from the Copernicus marine website) and added the corresponding new figures in Appendix C. We have also compared the results from ALES and from the conventional altimetry dataset in the Discussion and Conclusions section of the manuscript.

(Lines 555 – 560) "Regarding the comparison between the ALES-retracked and the along-track (L3) conventional altimetry datasets, we find that the former shows, on average, a 10% improvement, despite it being well within the margins of error. This improvement is most evident at Bodø, Kabelvåg and Tromsø, in northern Norway, where the agreement with the tide gauges improved by 19%, 23% and 24% respectively. The use of the ALES retracker to more satellite altimetry missions, in order to have more observations and to cover the period before July 2002, might help to reduce the uncertainties and return a more statistically significant result."

(Lines 701 – 704) "We do not expect such a consistency to depend on the ALES retracker since we find a comparable result when we use the along-track (L3) conventional altimetry product (Fig. C3). We rather suspect a dependence of the amplitude of the annual cycle on the bathymetry and, therefore, on the distance from the coast, as shown by Passaro et al. (2015) along the Norwegian sector of the Skagerrak."

From the optimization of the distances for the spatial averaging of the altimetry data it seems that inclusion of data more offshore than 20 km, which has been the a-priori fixed maximum distance, could even improve the correlation with the tide gauge data. Has this been tested?

We would like to thank you for the suggestion. We repeated the procedure to colocate the satellite altimetry at each tide gauge location, this time allowing the distance from the coast to range between 5 and 40 km (instead of a maximum of 20 km, as in the manuscript).

At 14 out 22 tide gauges, the result does not change: the optimized distance from the coast and from the tide gauge remains the same. The changes occur at three tide gauges in the south and west (Tredge, Bergen and Ålesund) and at five tide gauges in north of Norway (between Andenes and Vardø), where the optimized distance from the coast increases and ranges between 22.5 and 40 km.

Even though the optimized distance from the coast increases, the results in Figures 4, 6, 7 and 8 in the manuscript change little and do not modify the message of the manuscript. Indeed, the linear correlation coefficients increase by less than 2.5 %. The RMSD shows a larger, but still contained, improvement, with the greatest variation occurring at Tromsø, where the RMSD decreases from 2.0 to 1.7 cm (approximately 15 %). The amplitudes and phases of the annual cycle change by less than 9.5 % and less than 5 days respectively, and the linear trends by less than 7.5 %.

To address the comment, we have modified the Methods section of the manuscript where we have specified the sensitivity analysis performed:

(Lines 230 - 234) “We have then performed a sensitivity analysis and found only small differences between the results obtained applying a maximum distance of either 40 km or 20 km. To only focus on the observations over the continental shelf, we have selected the range of distances from the coast between 5 and 20 km. Similarly, we have performed a sensitivity test on the distance from the tide gauge allowing it to range between 15 and 400 km: as before, we have found little difference in the final results.”

That could mean, that conventional altimetry data could be of comparable quality because either the errors of the ALES-retracked altimetry data is still too high near the coast, or temporal variations are coherent for a wide stripe along the Norwegian coast and data away from the coast can do the job as well. So what is really the benefit from using the ALES-retracked data?

We would like to thank the reviewer for the comment which led to an extension of the manuscript. We extended our analysis to conventional altimetry: the performance is comparable in terms of the amplitude and phase of the annual cycle, while we find a 10% improvement in the sea level trend from ALES with respect to the one provided by conventional altimetry.

The text in the manuscript has changed.

(Lines 555 – 560) “Regarding the comparison between the ALES-retracked and the along-track (L3) conventional altimetry datasets, we find that the former shows, on average, a 10% improvement, despite it being well within the margins of error. This improvement is most evident at Bodø, Kabelvåg and Tromsø, in northern Norway, where the agreement with the tide gauges improved by 19%, 23% and 24% respectively. The use of the ALES retracker to more satellite altimetry missions, in order to have more observations and to cover the period before July 2002, might help to reduce the uncertainties and return a more statistically significant result.”

Minor issue:

In Figure 1 please mention, that the yellow diamonds are the hydrographic stations, and the red dots are the tide gauges.

We would like to thank you for the suggestion. We have modified Figure 1 and its caption accordingly.

Modification of Figures 4 and 5

The RMSD between the detrended and deseasoned SLA from satellite altimetry and each tide gauge is:

$$RMSD = \sqrt{\frac{\sum_{i=0}^{N}\left(SLA_{altimetry,i} - SLA_{tide\ gauge,i}\right)^2}{N}}$$

where N is the length of the time series derived by computing the difference between the detrended and deseasoned SLA from satellite altimetry and the tide gauge. When we computed the RMSD in the original manuscript, we did not account for the presence of missing values in the detrended and deseasoned SLA from satellite altimetry and from the tide gauges. Therefore, we set N equal to 192 (the number of months between January 2003 and December 2018). In the revised manuscript, we recomputed the RMSDs, this time accounting for the number of missing values in the time series. While this change only slightly affects Figs. 4B and 5B (but not the text describing them). Therefore, in the revised manuscript, we present the new version of Figs. 4 and 5.